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Evaluation of the Antibacterial Activity of Green Synthesized Selenium Nanoparticles

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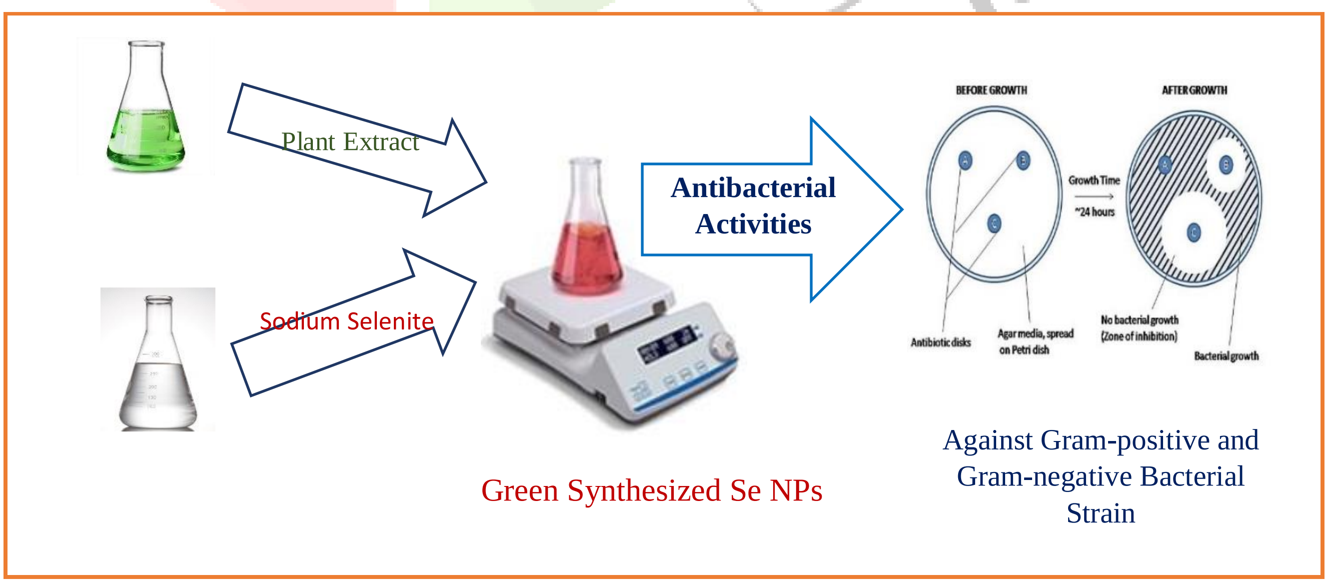
Abstract:

Green synthesis of selenium nanoparticles (Se-NPS) was done using plant extract in place of the capping and reducing agent and sodium selenite (Na_2SeO_3) as the selenium source. UV-Vis spectrum confirmed the formation of Se-NPs in the solution. The average particle size was estimated at nm according to the XRD pattern. The TEM shows the shape of Se-NPs. Antibacterial effects were observed against bacterial strains, including Staphylococcus aureus, Streptococcus mutans, Escherichia coli, and Pseudomonas aeruginosa. Based on the outcomes, the nanoparticles displayed stronger antibacterial activities towards the Gram-positive bacteria. This review article focuses on the bactericidal significance of such kinds of activities.

Keyword: Green synthesis, Selenium nanoparticles, plant extract, antibacterial activities



Introduction

Nanotechnology is a multidisciplinary research area with the potential to revolutionize several research fields, including medicine and biotechnologies. Current nanotechnology is involved in several emerging biomedical applications [1,2]. Nanotechnology is rapidly emerging in many fields such as food, agriculture, industry, medicine, electronics, drug delivery, therapeutics, and diagnostics.It is also considerable that nanoparticles can act as a carrier for antibiotics, vaccines, and adjuvants. Small sizes (about 1 to 100 nm) possess an increased surface area to volume ratio that results in a high biological activity and can enhance the interactions with microbial cells. Due to the misuse and overuse of antibiotics, as well as mutation, pollution, and changing environmental conditions, the exceedresistance to traditional medicines by microorganisms has become a threat to the global healthcare system [3]. The biosynthesis of nanoparticles using biological entities plant, bacteria, fungi, yeast, and algae emerges as sustainable, low cost, green substitute, and very well established [4,5]. Nanomaterials have been processed synthesized using various physical and chemical methods, separately from this green synthesis. To compare the three methods of synthesis, biological synthesis is the most inexpensive in nano-research and additionalsignificant than the physical and chemical synthesis of nanoparticles, flagging the way for a new age of bio-nanotechnology [6].Nowadays, the green synthesis of nanoparticles is being extensively explored because of their wide range of applicability and comparatively low toxicity beneficial for biomedical applications. Green synthesis of selenium nanoparticles (SeNPs) using different plant extracts is being done for discovering their activity in different biological fields. Because of their wide range of biological interactions, green synthesized SeNPs capped with bioactive Phyto molecules are widely investigated for their antimicrobial activity against human pathogenic or phytopathogenic bacteria as well as fungus[7,8].Besides, the development of a multidrug-resistant pattern among pathogens in general and aquatic pathogens, in particular, has raised the demand for a potential substitute for regularly used antibiotics. Hence, this study was intended to synthesize selenium nanoparticles in a green path method from sodium selenite salt by using the plant extract and to evaluate their antibacterial activity[9,10].

Biological Applications of Selenium Nanoparticles

	Plants	*Morphology of Se NPs*	*Size of Se NPs (nm)*	*Biological Applications*	*Refs.*
1	*Aloe vera*	*Spherical*	*125*	*Antibacterial and Antifungal*	*1*
2	*Allium sativum*	*Hollow and Spherical*	*7-45*	*Antimicrobial and Antibacterial*	*2*
3	*Abelmoschus esculentus*	*Spherical*	*30.7*	*Antibacterial*	*3*
4	*Aspergillus flavus and Candida albicans*	*Spherical*	*51.5*	*Antifungal*	*4*
5	*Azadirachta indica*	*Spherical and Smooth*	*~153 - ~278*	*Antibacterial*	*5*
6	*Azolla pinnata*	*Spherical*	*36.45*	*Antimicrobial and Antioxidant*	*6*
7	*Annona muricata*	*Spherical*	*120-160*	*Antioxidant and Antimicrobial*	*7*
8	*Brassica oleracea (Broccoli)*	*Spherical*	*10-25*	*Antioxidant and Anticarcinogenic*	*8*
9	*Blumeaaxillaris*	*Spherical (Aggregated)*	*248.1*	*Antibiotic and Antibacterial*	*9*
10	*Cassia auriculata*	*Face Centered Cubic*	*10-20*	*Antibacterial activity, Antihelmintic potential, Antipyretic Activity*	*10*
11	*Citrus delicioso (Kinnow)*	*Spherical, Cylindrical, Rectangular*	*40-100*	*Antibacterial and Antioxidant*	*11*
12	*Ceropegia bulbosa Roxb*	*Uniform Spherical*	*55.9*	*Antibacterial and Anticancer*	*12*
13	*Capparis decidua*	*Spherical*	*5-25*	*Antibacterial*	*13*
14	*Clausena dentata*	*Spherical*	*46.32-78.88*	*Insecticidal*	*14*
15	*Clove and Cinnamon*	*Spherical and Square*	*40-90*	*Antibacterial,Antifungala*	*15*

				nd Cytotoxic evaluation	
16	*Cannabis sativa*	*Spherical*	*140-150*	*Anti-Inflammatory and Antioxidant*	*16*
17	*Dillenia indica*	*Spherical*	*248*	*Antibacterial*	*17*
18	*Diospyros Montana*	*Spherical*	*4-60*	*Antimicrobial*	*18*
19	*Enterococcus faecalis*	*Spherical*	*29-195*	*Ant staphylococcal*	*19*
20	*Ephedra aphylla*	*Spherical and Tetragonal*	*13.95-26.26*	*Antimicrobial, Anticancer, Antibacterial, and Antioxidant*	*20*
21	*Enicostemaaxillare*	*Spherical*	*56.23-98.18*	*Antibacterial and Anticancer (against lung cancer cell --A549)*	*21*
22	*Emblica Officinalis*	*Spherical*	*15-40*	*Antimicrobial and Antioxidant*	*22*
23	*Fenugreek seed*	*Oval*	*50-150*	*Anticancer (breast cancer)*	*23*
24	*Gliocladiumroseum*	*Spherical, Hexagonal crystalline*	*20-80*	*Antifungal*	*24*
25	*Glycosmis pentaphylla*	*Spherical*	*Below 100*	*Antibacterial and Antioxidant*	*25*
26	*Hawthorn fruit*	*Spherical*	*113*	*Antitumor*	*26*
27	*Hibiscussabdariffa (roselle plant)*	*spherical, triangular,and hexagonal*	*20-50*	*Antioxidant*	*27*
28	*Juglans regia L.(Walnut)*	*Spherical*	*150*	*Antibacterial*	*28*
29	*Leucas lavaldulifolia*	*Spherical*	*56-75*	*Antibacterial*	*29*
30	*Moringa oleifera (Drumstick0*	*Spherical*	*23-35*	*Inhibition of CaCO-2 HePG-2 and Mcl-7 cell*	*30*
31	*Orthosiphon stamineus(Java tree leaves)*	*Spherical*	*88-141*	*Cytotoxicity against L6 Cell*	*31*
32	*Pelargonium zonale*	*Spherical*	*40-60*	*Antibacterial and Antifungal*	*32*
33	*Peltophorumpterocarpum*	*Spherical*	*400*	*Anticancer and Crop biofortification agent*	*33*
34	*Punica granatum*	*Spherical*	*20-60*	*Antimicrobial and*	*34*

				Antioxidant	
35	*Psidium guajava*	*Spherical*	*8-20*	*Antibacterial*	*35*
36	*Rosmarinus officinalis*	*Spherical*	*20-40*	*Antimicrobial And Antibacterial*	*36*
37	*Theobroma cacao L.*	*Spherical*	*1-3*	*Antioxidant*	*37*
38	*Urtica dioica (stinging nettle)*	*Spherical*		*Anticancer, Antifungal, and Antibacterial*	*38*
39	*Vitis vinifera*	*Spherical*	*5-20*	*Caping agent*	*39*
40	*Withaniasomnifera*	*Spherical*	*45-90*	*Antioxidant, Antibacterial, and Antiproliferative*	*40*
41	*Zingiber officinale*	*Spherical*	*100-150*	*Antibacterial and Antioxidant*	*41*

Green Synthesis and Characterization of Selenium Nanoparticles

The mostselectedportion of the plant to leave, bud, fruit, peel, nuts, seed, orpulpwas washed roughly with deionized water, dried in shade &grided in a mortar and then boiled in deionized water.Sometimes in other procedures, the continuous stirring condition without heating was applied. After this process, the solution was filtered or centrifugeand the collected liquid partwas used in the experiments. Plant extract exists by using different types of plants and their different parts as well as time and extraction temperature.

The formation of selenium nanoparticles in the reaction media wasanalyzed by diluting small aliquots of the sample with sterile distilled water using a UV-visible spectrophotometer After the complete reduction, the reaction media were centrifuged at 15000 rpm for 10 min and the aliquots were undergone repeated centrifugations using deionized water. Scanning Electron Microscope coupled with Energy Dispersive X-ray Spectroscopy was used to assess the shape and percentage of the synthesized selenium nanoparticles correspondingly. Transmission Electron Microscopic (TEM) measurements were made to find out the exact size and nature of the synthesized selenium nanoparticles. A Dynamic Light Scattering (DLS)particle size analyzer was used to obtain the exact values of the mean particle size, Zeta potential and Polydispersity Index (PDI) for the synthesized Se NPs.

Result and Discussion

Selenium nanoparticles (SeNPs) were synthesized from plant extract isan environmentally friendly, biocompatible, non-toxic, and practical technique.The bioactive phytochemicals from the plant extract acting as a capping agent block the accumulation of the nanoparticles and modify their biological activities The synthesized SeNPs found nano in size (7-400 nm), typically spherical in shape, and highly stable. Thesynthesized SeNPs exhibited potential antibacterial activity and possibly will be used as an antibacterial agent in the biomedical field.Also, SeNPs exhibits anti-cancer, anti-fungal, antimicrobial and antioxidant activities.Among, SeNPs have expandedinclusiveattraction due to their detailed medicinal, chemical, biological and pharmaceutical properties. Hence this study was focused on the green synthesis of SeNPs from plant extracts and the valuation of its antibacterial activity against certain specific primary and secondary pathogenic bacteria.

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Declarations

Conflict of interest: The authors declare that they have no conflict of interest.

Ethical approval: This has not been published elsewhere and is not currently under consideration for publication elsewhere

References

1. Fardsadegh, B., &Jafarizadeh-Malmiri, H. (2019). Aloe vera leaf extract mediated green synthesis of selenium nanoparticles and assessment of their in vitro antimicrobial activity against spoilage fungi and pathogenic bacteria strains. Green Processing and Synthesis, 8(1), 399-407.
2. Anu, K., Singaravelu, G., Murugan, K., & Benelli, G. (2017). Green-synthesis of selenium nanoparticles using garlic cloves (Allium sativum): biophysical characterization and cytotoxicity on vero cells. Journal of Cluster Science, 28(1), 551-563.
3. Ghaderi, R. S., Adibian, F., Sabouri, Z., Davoodi, J., Kazemi, M., AmelJamehdar, S., ... &Daroudi, M. (2021). Green synthesis of selenium nanoparticle by Abelmoschus esculentus extract and assessment of its antibacterial activity. Materials Technology, 1-9.

4. Bafghi, M. H., Darroudi, M., Zargar, M., Zarrinfar, H., & Nazari, R. (2021). Biosynthesis of selenium nanoparticles by Aspergillus flavus and Candida albicans for antifungal applications. Micro & Nano Letters, 16(14), 656-669.
5. Srivastava, N., & Mukhopadhyay, M. (2015). Biosynthesis and structural characterization of selenium nanoparticles using Gliocladiumroseum. Journal of Cluster Science, 26(5), 1473-1482.
6. Rajagopal, G., Nivetha, A., Ilango, S., Muthudevi, G. P., Prabha, I., &Arthimanju, R. (2021). Phytofabrication of selenium nanoparticles using Azolla pinnata: Evaluation of catalytic properties in oxidation, antioxidant and antimicrobial activities. Journal of Environmental Chemical Engineering, 9(4), 105483.
7. Rosaiah, G., Mangamuri, U. K., Sikharam, A. S., Devaraj, K., Kalagatur, N. K., &Kadirvelu, K. (2022). Biosynthesis of Selenium Nanoparticles from Annona muricata Fruit Aqueous Extract and Investigation of their Antioxidant and Antimicrobial potentials. Current Trends in Biotechnology and Pharmacy, 16(1), 101-107.
8. Sarkar, R. D., Lahkar, P., &Kalita, M. C. (2022). Glycosmis pentaphylla (Retz.) DC leaf extract mediated synthesis of selenium nanoparticle and investigation of its antibacterial activity against urinary tract pathogens. Bioresource Technology Reports, 17, 100894.
9. Dash, J. P., Mani, L., & Nayak, S. K. (2022). Antibacterial activity of Blumeaaxillaris synthesized selenium nanoparticles against multidrug resistant pathogens of aquatic origin. Egyptian Journal of Basic and Applied Sciences, 9(1), 65-76.
10. Anu, K., Devanesan, S., Prasanth, R., AlSalhi, M. S., Ajithkumar, S., &Singaravelu, G. (2020). Biogenesis of selenium nanoparticles and their anti-leukemia activity. Journal of King Saud University-Science, 32(4), 2520-2526.
11. Abu-Zeid, E. H., Fattah, D. M. A., Arisha, A. H., Ismail, T. A., Alsadek, D. M., Metwally, M. M., ... & Khalil, A. T. (2021). Protective prospects of eco-friendly synthesized selenium nanoparticles using Moringa oleifera or Moringa oleifera leaf extract against melamine induced nephrotoxicity in male rats. Ecotoxicology and Environmental Safety, 221, 112424.
12. Cittrarasu, V., Kaliannan, D., Dharman, K., Maluventhen, V., Easwaran, M., Liu, W. C., ... & Arumugam, M. (2021). Green synthesis of selenium nanoparticles mediated from Ceropegia bulbosa Roxb extract and its cytotoxicity, antimicrobial, mosquitocidal and photocatalytic activities. Scientific reports, 11(1), 1-15.
13. Madhumitha, B., Santhakumar, P., Jeevitha, M., &Rajeshkumar, S. (2021). Green synthesis of selenium nanoparticle using Capparis decidua fruit extract and its characterization using Transmission Electron Microscopy And UV-Visible spectroscopy. Research Journal of Pharmacy and Technology, 14(4), 2129-32.
14. Sowndarya, P., G. Ramkumar, and M. S. Shivakumar, Artificial cells, nanomedicine biotechnology 45.8 (2017): 1490-1495.

15. Sheikhlou, K., Allahyari, S., Sabouri, S., Najian, Y., &Jafarizadeh-Malmiri, H. (2020). Walnut leaf extract-based green synthesis of selenium nanoparticles via microwave irradiation and their characteristics assessment. Open Agriculture, 5(1), 227-235.
16. Mehta, H., Gupta, M., Kaur, P., Kaur, J., & Kaushal, A. N. (2021). Redox Modulatory Anti-Inflammatory Potential of Hempseed (Cannabis sativa) based Green Selenium Nanoparticles. Appl. Sci. Converg. Technol, 30, 81-86.
17. Chau, T. P., Veeraragavan, G. R., Narayanan, M., Chinnathambi, A., Alharbi, S. A., Subramani, B., ... &Pikulkaew, S. (2022). Green synthesis of zirconium nanoparticles using pomegranate peel extract and their antimicrobial and antioxidant potency. Environmental Research, 112771.
18. Alam, H., Khatoon, N., Raza, M., Ghosh, P. C., & Sardar, M. (2019). Synthesis and characterization of nano selenium using plant biomolecules and their potential applications. BioNanoScience, 9(1), 96-104.
19. Sharma, G., Sharma, A. R., Bhavesh, R., Park, J., Ganbold, B., Nam, J. S., & Lee, S. S. (2014). Biomolecule-mediated synthesis of selenium nanoparticles using dried Vitis vinifera (raisin) extract. Molecules, 19(3), 2761-2770.
20. El-Zayat, M. M., Eraqi, M. M., Alrefai, H., El-Khateeb, A. Y., Ibrahim, M. A., Aljohani, H. M.&Elshaer, M. M. (2021). The Antimicrobial, antioxidant, and anticancer activity of greenly synthesized selenium and zinc composite nanoparticles using Ephedra aphylla extract. Biomolecules, 11(3), 470.
21. Perumal, S., Gopal Samy, M. V., & Subramanian, D. (2021). Selenium nanoparticle synthesis from endangered medicinal herb (Enicostemaaxillare). Bioprocess and Biosystems Engineering, 44(9), 1853-1863.
22. Gunti, L., Dass, R. S., &Kalagatur, N. K. (2019). Phytofabrication of selenium nanoparticles from Emblica officinalis fruit extract and exploring its biopotential applications: antioxidant, antimicrobial, and biocompatibility. Frontiers in microbiology, 10, 931.
23. Ramamurthy, C. H., Sampath, K. S., Arunkumar, P., Kumar, M. S., Sujatha, V., Premkumar, K., &Thirunavukkarasu, C. (2013). Green synthesis and characterization of selenium nanoparticles and its augmented cytotoxicity with doxorubicin on cancer cells. Bioprocess and biosystems engineering, 36(8), 1131-1139.
24. Dhanraj, G., &Rajeshkumar, S. (2021). Anticarcinogenic effect of selenium nanoparticles synthesized using brassica oleracea. Journal of Nanomaterials, 2021.
25. Hashem, A. H., & Salem, S. S. (2021). Green and ecofriendly biosynthesis of selenium nanoparticles using Urtica dioica (stinging nettle) leaf extract: Antimicrobial and anticancer activity. Biotechnology journal, 2100432.

26. Kirupagaran, R., Saritha, A., &Bhuvaneswari, S. (2016). Green synthesis of selenium nanoparticles from leaf and stem extract of leucas lavandulifolia sm. and their application. Journal of Nanoscience and Technology, 224-226.
27. Fan, D., Li, L., Li, Z., Zhang, Y., Ma, X., Wu, L., ... & Guo, F. (2020). Biosynthesis of selenium nanoparticles and their protective, antioxidative effects in streptozotocin induced diabetic rats. Science and Technology of Advanced Materials, 21(1), 505-514.
28. Mulla, N. A., Otari, S. V., Bohara, R. A., Yadav, H. M., & Pawar, S. H. (2020). Rapid and size-controlled biosynthesis of cytocompatible selenium nanoparticles by Azadirachta indica leaves extract for antibacterial activity. Materials Letters, 264, 127353.
29. Sivakumar, C., &Jeganathan, K. (2018). In-vitro cytotoxicity of java tea mediated selenium nanoballs against L6 cell lines. Journal of Drug Delivery and Therapeutics, 8(6), 195-200.
30. Kokila, K., Elavarasan, N., & Sujatha, V. (2017). Diospyros montana leaf extract-mediated synthesis of selenium nanoparticles and their biological applications. New Journal of Chemistry, 41(15), 7481-7490.
31. Fardsadegh, B., &Jafarizadeh-Malmiri, H. (2019). Aloe vera leaf extract mediated green synthesis of selenium nanoparticles and assessment of their in vitro antimicrobial activity against spoilage fungi and pathogenic bacteria strains. Green Processing and Synthesis, 8(1), 399-407.
32. Deepa, B., & Ganesan, V. (2015). Bioinspiredsynthesis of selenium nanoparticles using flowers of Catharanthus roseus (L.) G. Don. and Peltophorumpterocarpum (DC.) Backer ex Heyne–a comparison. Int. J. Chem. Tech. Res, 2.
33. Alagesan, V., & Venugopal, S. (2019). Green synthesis of selenium nanoparticle using leaves extract of withaniasomnifera and its biological applications and photocatalytic activities. Bionanoscience, 9(1), 105-116.
34. Adibian, F., Ghaderi, R. S., Sabouri, Z., Davoodi, J., Kazemi, M., Ghazvini, K., ... &Darroudi, M. (2022). Green synthesis of selenium nanoparticles using Rosmarinus officinalis and investigated their antimicrobial activity. BioMetals, 1-12.
35. Mellinas, C., Jiménez, A., &Garrigós, M. D. C. (2019). Microwave-assisted green synthesis and antioxidant activity of selenium nanoparticles using Theobroma cacao L. bean shell extract. Molecules, 24(22), 4048.
36. Ikram, M., Raja, N. I., Mashwani, Z. U. R., Omar, A. A., Mohamed, A. H., Satti, S. H., & Zohra, E. (2022). Phytogenic Selenium Nanoparticles Elicited the Physiological, Biochemical, and Antioxidant Defense System Amelioration of Huanglongbing-Infected ‘Kinnow’Mandarin Plants. Nanomaterials, 12(3), 356.
37. Shoeibi, S., &Mashreghi, M. (2017). Biosynthesis of selenium nanoparticles using Enterococcus faecalis and evaluation of their antibacterial activities. Journal of Trace Elements in Medicine and Biology, 39, 135-139.

38. Menon, S., Agarwal, H., Kumar, S. V., &Rajeshkumar, S. (2019). Biomemetic synthesis of selenium nanoparticles and its biomedical applications. In Green Synthesis, Characterization and Applications of Nanoparticles (pp. 165-197). Elsevier.
39. Pereira, W. D., Rajasekar, A., &Rajeshkumar, S. (2020). Green Synthesis Of Selenium Nanoparticles (Senps) Using Aqueous Extract Of Clove And Cinnamon. Plant Cell Biotechnology And Molecular Biology, 85-91.
40. Chau, T. P., Veeraragavan, G. R., Narayanan, M., Chinnathambi, A., Alharbi, S. A., Subramani, B., ... &Pikulkaew, S. (2022). Green synthesis of zirconium nanoparticles using pomegranate peel extract and their antimicrobial and antioxidant potency. Environmental Research, 112771.
41. Menon, S., KS, S. D., Agarwal, H., & Shanmugam, V. K. (2019). Efficacy of biogenic selenium nanoparticles from an extract of ginger towards evaluation on anti-microbial and anti-oxidant activities. Colloid and Interface Science Communications, 29, 1-8.
42. Ali, Ruaha M., and Shurooq S. Mahmood, Biochem. Cell. Arch. 21, 2 (2021): 3677-3683
43. Dash, Jyoti Prakash, Lopamudra Mani, and Sukanta Kumar Nayak, Egyptian Journal of Basic and Applied Sciences 9.1 (2022): 65-76
44. Pyrzynska, K., &Sentkowska, A. (2021). Biosynthesis of selenium nanoparticles using plant extracts. Journal of Nanostructure in Chemistry, 1-14.
45. Ikram, M., Javed, B., Raja, N. I., &Mashwani, Z. U. R. (2021). Biomedical potential of plant-based selenium nanoparticles: a comprehensive review on therapeutic and mechanistic aspects. International Journal of Nanomedicine, 16, 249.
46. Boroumand, S., Safari, M., Shaabani, E., Shirzad, M., &Faridi-Majidi, R. (2019). Selenium nanoparticles: synthesis, characterization and study of their cytotoxicity, antioxidant and antibacterial activity. Materials Research Express, 6(8), 0850d8.
47. Kirupagaran, R., Saritha, A., &Bhuvaneswari, S. (2016). Green synthesis of selenium nanoparticles from leaf and stem extract of leucas lavandulifolia sm. and their application. Journal of Nanoscience and Technology, 224-226.
48. Menon, S., Agarwal, H., Rajeshkumar, S., Jacquline Rosy, P., & Shanmugam, V. K. (2020). Investigating the antimicrobial activities of the biosynthesized selenium nanoparticles and its statistical analysis. Bionanoscience, 10(1), 122-135.
49. Afzal, B., & Fatma, T. (2021). Selenium Nanoparticles: Green Synthesis and Exploitation. In Emerging Technologies for Nanoparticle Manufacturing (pp. 473-484). Springer, Cham.
50. Rangrazi, A., Bagheri, H., Ghazvini, K., Boruziniat, A., &Darroudi, M. (2020). Synthesis and antibacterial activity of colloidal selenium nanoparticles in chitosan solution: a new antibacterial agent. Materials Research Express, 6(12), 1250h3.

51. Zhang, H., Li, Z., Dai, C., Wang, P., Fan, S., Yu, B., & Qu, Y. (2021). Antibacterial properties and mechanism of selenium nanoparticles synthesized by Providencia sp. DCX. Environmental Research, 194, 110630.
52. Alvi, G. B., Iqbal, M. S., Ghaith, M. M. S., Haseeb, A., Ahmed, B., & Qadir, M. I. (2021). Biogenic selenium nanoparticles (SeNPs) from citrus fruit have anti-bacterial activities. Scientific Reports, 11(1), 1-11.
53. PonMatheswari, P., Jenit Sharmila, G., &Murugan, C. (2022). Green synthesis of selenium nanoparticles using Delonix regia and Nerium oleander flower extract and evaluation of their antioxidant and antibacterial activities. Inorganic and Nano-Metal Chemistry, 1-12.
54. Cui, D., Liang, T., Sun, L., Meng, L., Yang, C., Wang, L., ... & Li, Q. (2018). Green synthesis of selenium nanoparticles with extract of hawthorn fruit induced HepG2 cells apoptosis. Pharmaceutical biology, 56(1), 528-534.
55. Al Jahdaly, B. A., Al-Radadi, N. S., Eldin, G. M., Almahri, A., Ahmed, M. K., Shoueir, K., &Janowska, I. (2021). Selenium nanoparticles synthesized using an eco-friendly method: dye decolorization from aqueous solutions, cell viability, antioxidant, and antibacterial effectiveness. journal of materials research and technology, 11, 85-97.
56. Geoffrion, L. D., Hesabizadeh, T., Medina-Cruz, D., Kusper, M., Taylor, P., Vernet-Crua, A., ... &Guisbiers, G. (2020). Naked selenium nanoparticles for antibacterial and anticancer treatments. ACS omega, 5(6), 2660-2669.
57. Ashengroph, M., & Hosseini, S. R. (2021). A newly isolated Bacillus amyloliquefaciens SRB04 for the synthesis of selenium nanoparticles with potential antibacterial properties. International Microbiology, 24(1), 103-114.
58. Verma, P. (2015). A review on synthesis and their antibacterial activity of Silver and Selenium nanoparticles against biofilm-forming Staphylococcus aureus. World J. Pharm. Pharmaceut. Sci, 4, 652-677.
59. VinkovićVrček, I. (2018). Selenium nanoparticles: Biomedical applications. In Selenium (pp. 393-412). Springer, Cham.
60. Hernández-Díaz, J. A., Garza-García, J. J., León-Morales, J. M., Zamudio-Ojeda, A., Arratia-Quijada, J., Velázquez-Juárez, G., ... & García-Morales, S. (2021). Antibacterial Activity of Biosynthesized Selenium Nanoparticles Using Extracts of Calendula officinalis against Potentially Clinical Bacterial Strains. Molecules, 26(19), 5929.